HEALTH&SCIENCE

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BLOWING IN THE WIND

Every year, the United States and the Caribbean get a dusting from Asian and African deserts. The results are not pretty and may be getting worse.

By DENNIS O'BRIEN
SUN STAFF

It's a world traveler that affects climate and may have wiped out the dinosaurs.

Dust, scientists say, is more than something vacuumed from under our beds.

This time each year, dust from Africa hitches a ride on trade winds across the Atlantic Ocean to Florida, where it strengthens thunderstorms, pollutes the air and may be damaging sea corals. Dust storms in China routinely affect Pacific Ocean chemistry. This spring, they clouded the skies over Colorado.

But despite decades of research, scientists say, there is still much to learn about dust and its effect on our lives.

"Dust, with regard to climate, is just not as simple as you might expect," said Steven M. Babin, a researcher at the Johns Hopkins University Applied Physics Laboratory in Laurel.

Dust particles that travel the globe are different from the dust in your home. Household dust consists of fibers from clothing, carpets and upholstery, as well as particles of skin, hair, pollens, mold, wood and paint. Dust that crosses the oceans is made up mostly of tiny sand and soils.

"It can have the consistency of finely milled flour," said Ben Barnum, another Hopkins APL researcher who has developed dust forecasting systems for the military.

But the world's dust problem may be getting worse. As parts of the globe become drier, millions of acres of productive land in Africa and Asia are lost each year, raising more dust as deserts expand, forests disappear and soils erode, according to a United Nations panel.

A U.N. report released last week ranks desert growth and land degradation as one of the world's top environmental problems. Experts say that droughts, population growth and global warming are making things worse, drying up areas and producing more dust.

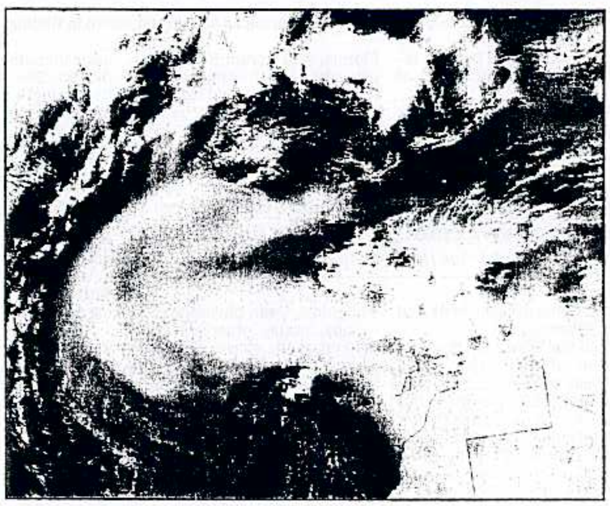
"While warming might increase rainfall in some parts of the world, areas that are [See Dust, 5D]

Dust migration

Beginning each spring, dust raised by windstorms in Africa migrates across the Atlantic and is deposited in the Caribbean and southeastern United States. Winds that sweep out of Asia and across the Pacific bring dust to the western United States beginning in March.

Wind direction (see below) is determined by solar heating and the Earth's rotation. Belts of wind flow in the same general direction year round, but shift with the seasons, taking a northerly track in summer and a southerly one in winter.

The intercontinental transport of dust has been going on for millions of years. One effect is that much of the Caribbean soil originated as dust in Africa. On the East Coast of the United States, small amounts of African dust sometimes carry as far north as New England.



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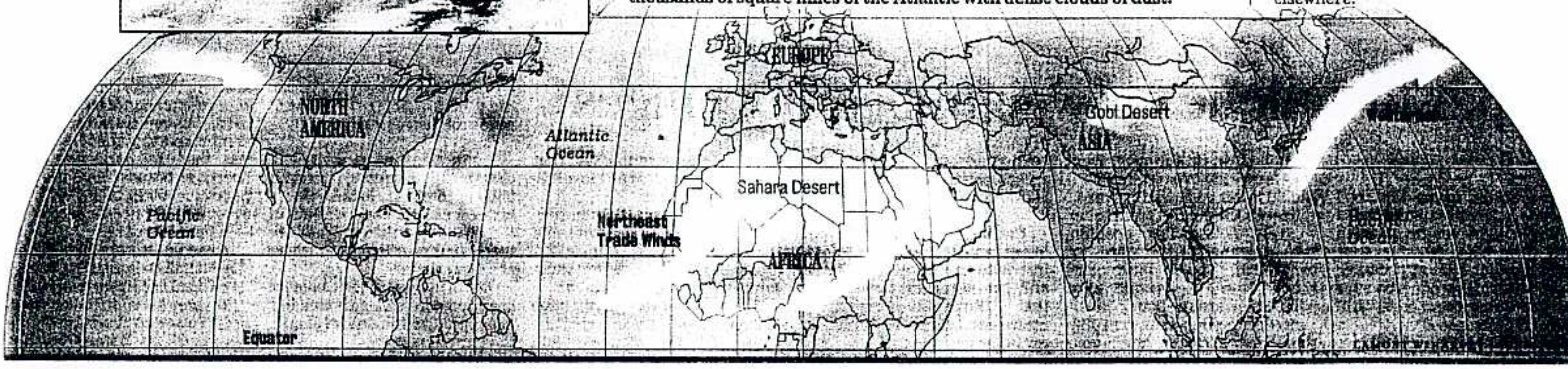
Satellite imagery used by the military and for weather forecasting shows large dust storms, such as a storm that blew from China across Korea and Japan (left). The dust from China mingled with smoke from fires in Korea as it passed. Storms and rising warm air can lift dust as high as 20,000 feet over northwest Africa (above) and blanket hundreds of thousands of square miles of the Atlantic with dense clouds of dust.

Dust effects

- Beginning each spring, African dust contributes to air pollution in Florida, and Asian dust adds to haze as far inland as Colorado.
- Microscopic organisms such as bacteria and fungi may be carried on the wind with dust. A few are believed to threaten U.S. crops, but scientists believe most are rendered harmless by the sun's rays.
- Thunderstorms gain intensity from dust; the particles increase the number and power of updrafts of warm, moist air.
- Iron in airborne dust may buffer global warming by encouraging the growth of phytoplankton, a tiny marine organism that captures and restricts release of carbon dioxide.
- Extensive droughts since the 1960s in Africa and Asia are turning millions of acres of previously productive land into dust that is transported elsewhere.



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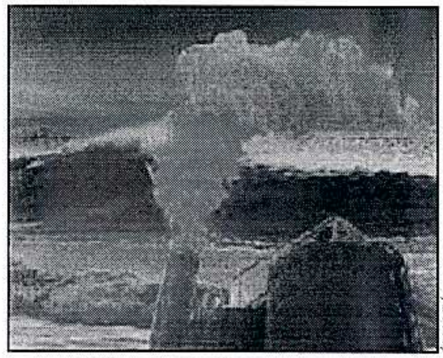

Iron sulfate mixed with ocean water produces phytoplankton, which draw carbon dioxide from the atmosphere

From Don Knapp
CNN San Francisco Bureau Chief

(CNN) -- Scientists are trying to determine whether treating ocean water with iron sulfate is a quick fix for global warming or a Pandora's Box that could lead to further environmental problems.

Scientists and entrepreneurs alike see opportunity in the results of a mid-1990s experiment in which Moss Landing Marine Laboratories spread relatively small amounts of iron sulfate across a 100-square-mile patch of ocean.

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Environmental issues

"By day four, five, the oceans had turned green," said Kenneth Coale, oceanographer and acting director of Moss Landing Marine Laboratory. "(It) had turned from what is an electric blue, characterizing the equatorial Pacific, to something bright green. You could smell the difference."

Increased plant biomass, production

The iron-treated ocean rapidly produced tiny ocean plants called phytoplankton that draw carbon dioxide, a greenhouse gas associated with global warming, from the atmosphere. Coale estimates the experiment increased plant biomass by a factor of almost 40 and plant production by a factor of five or six.

"In nine days, we had grown thousands of tons of phytoplankton and biomass and drawn down atmosphere carbon dioxide," he said.

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Lab director John Martin originally proposed the experiment. He was widely quoted as saying, "Give me a half tanker of iron, and I'll create an ice age,".

But Martin died before getting to test his theory of whether organisms feeding on that much phytoplankton could rob the ocean of oxygen and in turn, kill fish.

As the U.S. Department of Energy monitors the experiments, it hypothesizes that carbon may be locked up and sent to the bottom of the ocean or re-released back into the atmosphere.

"We can turn the ocean green, but we really don't have a clue as to where the carbon goes," said Jim Bishop of the Department of Energy.

Until they figure that out, researchers say it may be risky to try to turn down the global thermostat by turning up phytoplankton growth.

Coale's group will return to the ocean for another 100-square-mile iron fertilization experiment in about a year.

"We need to understand whether this is the way that nature turned on and off global warming in the past, and we need experiments of a relatively large scale in order to answer those questions," Coale said.

A potential billion dollar market

Also taking to the waters is Greensea Venture Inc. and chemical engineer Michael Markels, who will spread his proprietary mixture of chelated iron over 5,000 square miles of ocean in a $7 million experiment.

Markels said he's interested as much in product development as academic research, but at stake is a potential market worth billions of dollars in "credits" for carbon dioxide-producing industries.

Industry pays from $30 to $100 to rid its exhaust gases of carbon dioxide, but Markels believes the greenhouse gas can be removed for about $2 a ton by treating the oceans with iron.

"We've thought coal companies might be interested in this because they could sort of have a little license attached to their coal that says, when you burn this coal, no net CO2 would go into the atmosphere because we've already taken it out," Markels said.

Markels said he'll ask academic researchers, including Moss Landing Marine Laboratories, to participate in the evaluation of his experiment, but Coale may be leery of Markels' approach to global warming solutions.

"Iron fertilization for geo-engineering, or fish production, has been driven by a kind of quick-buck philosophy that is not necessarily sensitive to downstream effects," he said.

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'Fertilizing' oceans could affect food chain, scientists say

Impact of adding iron is little understood

Bruce Lieberman

UNION-TRIBUNE STAFF WRITER

February 14, 2004

SEATTLE – The idea seems simple enough: Add iron to the oceans so they absorb more carbon dioxide from the atmosphere than they normally do, and you've found a way to cut the amount of greenhouse gases warming the planet.

But, like most things in science, it's not that easy.

That was the word yesterday from scientists gathered for the annual meeting of the American Association for the Advancement of Science.

Small-scale studies in recent years have shown that adding iron to small patches of ocean triggers blooms of phytoplankton, single-celled algae that absorb carbon from carbon dioxide in the atmosphere as they grow in the sunlit, upper ocean.

But those experiments say little about the impact on larger marine life, or what might happen to the entire food chain by seeding ocean water with tanker-loads of iron particles.

"We understand a little bit about how iron fertilization works with microscopic organisms on small scales," said Mike Landry, a researcher from the Scripps Institution of Oceanography in La Jolla. "We don't know how this scales up toward large organisms."

Other scientists said that seeding the oceans with iron in one place could profoundly alter the food chain in other parts of the ocean.

Some studies even suggest that adding iron to the oceans could lead to the creation of nitrous oxide and methane, greenhouse gases that are more potent than carbon dioxide at trapping heat from the sun.

"The (nitrous oxide) that you create is worse than the Co2 that you sequester," Sallie Chisholm, a researcher at the Massachusetts Institute of Technology, said of one study that estimated the outcome of seeding the oceans with iron over 100 years.

Scientists introduced the idea of "fertilizing" the oceans with iron in 1990. But small-scale experiments in the Southern Ocean near Antarctica – where currents keep the iron in a limited area – have raised more questions than they have answered, scientists say.

Nevertheless, evidence suggesting that adding iron does increase phytoplankton has captured the imagination of policy-makers and business people.

Finding ways to take carbon dioxide, a main byproduct of the burning of fossil fuels, out of the atmosphere and hiding it away – either by burying it in the ground or placing it deep in the ocean – has intrigued the federal Department of Energy as a "third option" for dealing with rising greenhouse gases.

Increasing fuel efficiency, or turning to cleaner, carbon-free fuels such as nuclear, solar and wind power, may not be enough to stem the tide, according to an Energy Department briefing paper on the subject.

The oceans are attractive targets in part because they absorb so much of the carbon cycled between Earth and its atmosphere.

Phytoplankton, like terrestrial plants, convert carbon dioxide from the atmosphere into organic carbon during photosynthesis. Although they make up less than 1 percent of the Earth's biomass, phytoplankton are responsible for roughly half of Earth's natural carbon cycle.

The oceans are huge "sinks" for carbon because when phytoplankton die, they sink deep into the oceans, carrying the carbon in their tissues with them – out of circulation for long periods of time.

But adding iron to the oceans could change that system, scientists said. Boosting phytoplankton populations by fertilizing oceans could lead to more predation by zooplankton.

Zooplankton, in turn, are eaten by larger sea creatures (whales among them) that then release carbon dioxide back into the atmosphere as they breathe. Phytoplankton will never have enough time to die naturally and sink to the oceans' interior, and the carbon they hold will be returned to the atmosphere as carbon dioxide, they said.

If the oceans end up taking in more carbon than they do now, that could lead to other problems. Oxygen from the carbon dioxide that oceans absorb will be consumed by bacteria, leading to an increase in methane, Chisholm said. Methane, eventually released into the atmosphere, is 22 times more potent than carbon dioxide as a greenhouse gas, she said.

"It's certainly not the answer to our problem," Chisholm said of fertilizing the oceans with iron. "This is the problem: We're putting too much carbon dioxide into the atmosphere."

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Can Iron-Enriched Oceans Thwart Global Warming?

John Roach
for National Geographic News
June 9, 2004

Virtually all life in the world's oceans is directly or indirectly dependent on one-celled plants called phytoplankton. These plants, which live at the ocean surface, feed on ocean nutrients to survive.

But about 20 to 30 percent of these crucial nutrients sink out of reach of the phytoplankton each year, according to Jorge Sarmiento, a professor of atmospheric and ocean sciences at Princeton University in New Jersey.

Through his research, Sarmiento is trying to tease out the details of how the ocean supplies the nutrients that phytoplankton need to survive and, in turn, support everything else that makes a living in or off the ocean.

Sinking Nutrients

Sarmiento equates the sinking nutrients in the ocean to leaves falling off trees. Bacteria break down the organic matter of fallen leaves, releasing their nutrients for reuse by plants in the future.

"The big difference in the ocean is that much of the organic matter sinks out of reach of the surface ocean, where there is enough light for photosynthesis," Sarmiento said. "Thus when bacteria break this organic matter down back into dissolved nutrients, the phytoplankton cannot get at the nutrients."

Ken Buesseler is a marine chemist at the Woods Hole Oceanographic Institution in Massachusetts who studies the flow of sinking particles. Buesseler notes that once particles like nutrients sink to the deep ocean, they remain isolated for hundreds to thousands of years.

"Ocean currents determine the mixing rates and how long certain deep waters remain isolated," Buesseler said.

According to Sarmiento's research, ocean currents eventually transport a large fraction of these deep-water nutrients to ocean around Antarctica. There, the nutrients return to the surface and are redistributed throughout the world's oceans.

Iron Hypothesis

Buesseler recently applied his study of the nutrient flow to the so-called iron hypothesis. Some scientists argue that by adding iron to areas of the ocean that are iron deficient, populations of iron-starved phytoplankton would blossom.

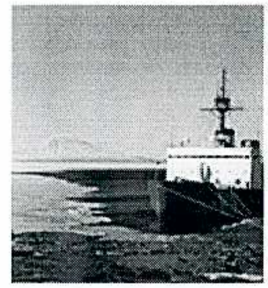
In turn, these robust phytoplankton populations would help fight global warming by removing carbon dioxide from the atmosphere via increased photosynthesis. (The process entails plants using energy from the sun to convert carbon dioxide and nutrients into complex organic compounds to form new plant material.)

Some of this carbon sinks to the deep ocean along with other nutrients as phytoplankton die. As a result, some scientists hypothesize that increased phytoplankton would isolate additional carbon in the deep ocean for hundreds or thousands of years.

"These particles carry carbon and other associated elements from the surface to the deep sea," Buesseler said. "If the newly formed carbon—essentially organic matter—were to remain in the surface ocean, marine bacteria would simply consume this organic matter and convert it back to carbon dioxide."

To test the hypothesis that iron-enriched oceans result in more carbon sinking to the deep ocean, international teams of scientists have traveled to the waters around Antarctica and actively added iron to encourage phytoplankton blooms.

Buesseler and his colleagues participating in the experiment studied how much carbon sank to the deep ocean in these iron-enriched areas versus non-iron-enriched areas.



One-celled ocean plants known as phyt from atmospheric carbon dioxide, a kno Scientists recently conducted experimer controversial theory of whether enrichin an ocean nutrient, would encourage phy trap sufficient atmospheric carbon to reg change. Pictured above is the U.S. Coa *Star,* one of three ships used by scientis near Antarctica.

Photograph by Leah Houghton, copyrigl Oceanographic Institution

Funding for this Earth-systems science s the National Science Foundation.
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"We measured an increase in carbon flux in the iron-fertilized patch and did not see an equivalent increase in flux outside in the control stations," he said. "However, this increase was not particularly large."

According to Buesseler's calculations, about 900 more tons (816 metric tons) of carbon sank to the deep sea as a result of the experiment. Humans emit about ten million times that amount of carbon into the atmosphere each year through the burning of fossil fuels.

Sink Importance

Buesseler said it is possible to enrich larger areas of the oceans around Antarctica with iron, but that the net result would likely be the removal of only a few percent of the extra carbon in the atmosphere.

However, he has not given up on the idea of using carbon sinks to combat climate change.

"We need to explore ways to decrease inputs of carbon dioxide to the atmosphere and enhance carbon sinks," Buesseler said. "The ocean is one of the sinks and the link between the surface ocean and deep ocean with respect to these sinking particles is one of the most poorly understood areas of ocean science."

A paper by Buesseler and his colleagues describing their research appeared in the April 16 issue of the journal *Science*.

For more news on oceans, scroll down

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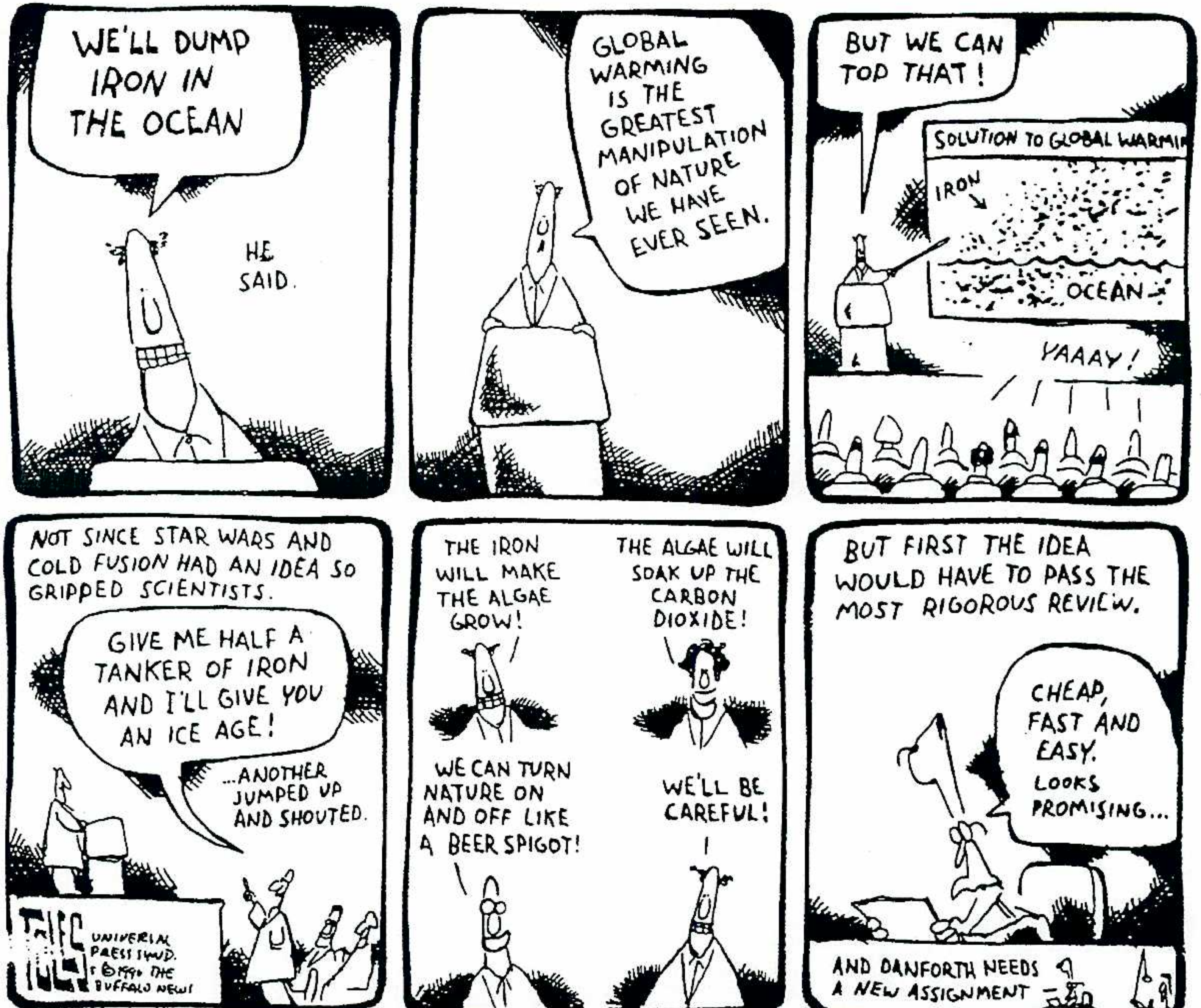
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